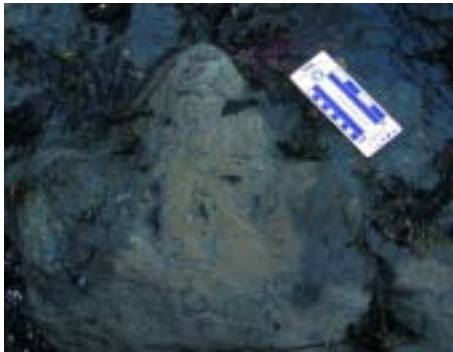






Photograph courtesy of Anthony Fiorillo

Figure 1. Coastal exposure of the Chignik Formation in Aniakchak National Monument.



Photograph courtesy of Anthony Fiorillo

Figure 2. Three-toed track attributable to a duck-billed dinosaur.

Left: View of lower Ukak Falls. The rocks in the foreground represent an ancient delta complex within the Naknek Formation.

Photograph courtesy of Anthony Fiorillo

New Frontiers, Old Fossils: Recent Dinosaur Discoveries in Alaska National Parks

by Anthony R. Fiorillo, Russell Kucinski, and Troy R. Hamon

Introduction

Alaska is well known for its rugged geologic beauty and plentiful biological wonders. The National Park Service administers approximately 54 million acres of land in Alaska that includes some of the most fossiliferous rocks in the state. Recognizing that much still needs to be learned about the fossil resources in parks, the Alaska Region of the National Park Service has partnered with the Dallas Museum of Natural History, the University of Alaska Museum of the North, and other institutions to develop a better understanding of paleontology in several Alaska parks.

Initial results suggest that a wealth of basic paleontological information is still to be gathered in Alaska parks (Fiorillo *et al.* 2004, Fiorillo and Parrish 2004). Arguably, with respect to the public's interest, the most significant finds in the Alaska national parks have been the discovery of dinosaur remains in two parks: Aniakchak National

Monument and Preserve and Katmai National Park and Preserve. Here we highlight those discoveries that are requiring scientists to reevaluate their conclusions about dinosaurs in Alaska during the Jurassic and Cretaceous periods.

Aniakchak National Monument and Preserve

Aniakchak National Monument and Preserve, approximately 600,000 acres, is one of the most remote, and thus least visited, parks in the National Park System. The park was established in 1980 because of the volcanic features in the region, the most notable of which is the 6-mile (10 km) wide Aniakchak Caldera, a 2,000 feet (600 m) deep circular feature that is the result of the collapse of a magma chamber. In addition to the prominent volcanic features of the park, there are sedimentary rocks ranging in age from the Late Jurassic Naknek Formation to the Eocene Tolstoi Formation (Detterman *et al.* 1981, Wilson *et al.* 1999), representing a period of time from approximately 150–45 million years ago. Of

these sedimentary rock units, the Upper Cretaceous Chignik Formation contains the first record of dinosaurs of any kind found in national parks in Alaska.

Alaska contains many geologic terranes that appear to have originated elsewhere and traveled by various movements of tectonic plates to their present locations. Paleomagnetic analysis of the Upper Cretaceous and Lower Tertiary rocks of Aniakchak, however, suggests that the Chignik Formation was formed at approximately its current latitude (Hillhouse and Coe 1994).

The Chignik Formation was named by Atwood (1911) for rocks exposed in the vicinity of Chignik Bay, southwest of what is now Aniakchak National Monument. The rock unit is a cyclic sequence of rocks representing predominately shallow to nearshore marine environments in the lower part and predominately continental environments in the upper part of the section (Figure 1).

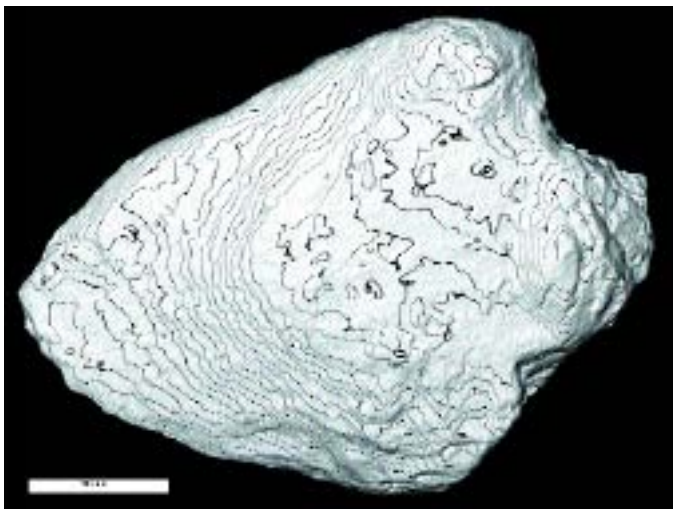
The age of the Chignik Formation, based on the occurrence of particular fossil



Photograph courtesy of Anthony Fiorillo

...fossil tracks, along with the more well-known dinosaur discoveries on the Colville River of northern Alaska, document the existence of an extensive high-latitude terrestrial ecosystem capable of supporting large-bodied herbivores.

Such an ecosystem stretched for hundreds of miles over a region roughly composed of present day Alaska and supported non-migrating herds of hadrosaurs.



Photograph courtesy of Anthony Fiorillo

Figure 3a. Above Left: Slab of Chignik Formation containing one footprint and two handprints of a duck-billed dinosaur.

Figure 3b. Left: Contour of a cast of the footprint shown in Figure 3a. Notice the three toes and the elongated heel. The elongated heel is attributed to a sliding motion of the foot during the initial footfall.

Figure 4. Opposite Page: Reconstruction of a duck-billed dinosaur.

marine bivalves, ammonites, and plant fossils, is considered to be late Campanian to early Maastrichtian (Detterman *et al.* 1996, Fiorillo and Parrish 2004) or roughly 77–68 million years old. The age of this sequence is approximately the same age as some of the better known dinosaur locations along the Colville River of northern Alaska (Fiorillo and Parrish 2004).

Cretaceous dinosaurs, reported for the first time from southwestern Alaska in Aniakchak as a set of footprints and handprints (Figures 2 and 3), are attributable to a duck-billed dinosaur called a hadrosaur (Figure 4) (Fiorillo 2004, Fiorillo and Parrish 2004). Fortuitously, these tracks are preserved in association with fossil leaf litter that includes several leaves with feeding trails of herbivorous insects and a standing forest. Therefore, several facets of an ancient terrestrial ecosystem are preserved in this one exposure of the Chignik Formation in the monument. The Chignik Formation occurs throughout a large portion of the monument and more survey work will likely yield additional insight into this ancient ecosystem.

Because most of Alaska was near its present latitude or higher during the later Cretaceous period, perhaps the most significant contribution is that the fossil tracks, along with the more well-known dinosaur discoveries on the Colville River of northern Alaska, document the existence of an extensive high-latitude terrestrial ecosystem capable of supporting large-bodied herbivores. Such an ecosystem stretched for hundreds of miles over a region roughly composed of present day Alaska and supported non-migrating herds of hadrosaurs

(Fiorillo and Gangloff 2001).

Most of the dinosaur groups in North America during the Cretaceous appear to have originated in Asia and migrated to the American continents across a land bridge. In the much more recent Pleistocene, such a land bridge has been referred to as Beringia. The footprints in Aniakchak National Monument and Preserve, in conjunction with the discoveries in the northern part of the state, suggest that the antiquity of Beringia is rooted in the Cretaceous (Fiorillo 2004).

Katmai National Park and Preserve

Katmai National Park and Preserve was established in 1918 and expanded four times, the most recent in 1980. It is one of the oldest national parks in Alaska. The proclamation of this unit as a national monument was based on the enormous 1912 eruption of Novarupta (Adleman 2002). The subsequent expansions recognized that important resources of the park included not only those related to the volcanic activity, but also elements of the modern flora and fauna.

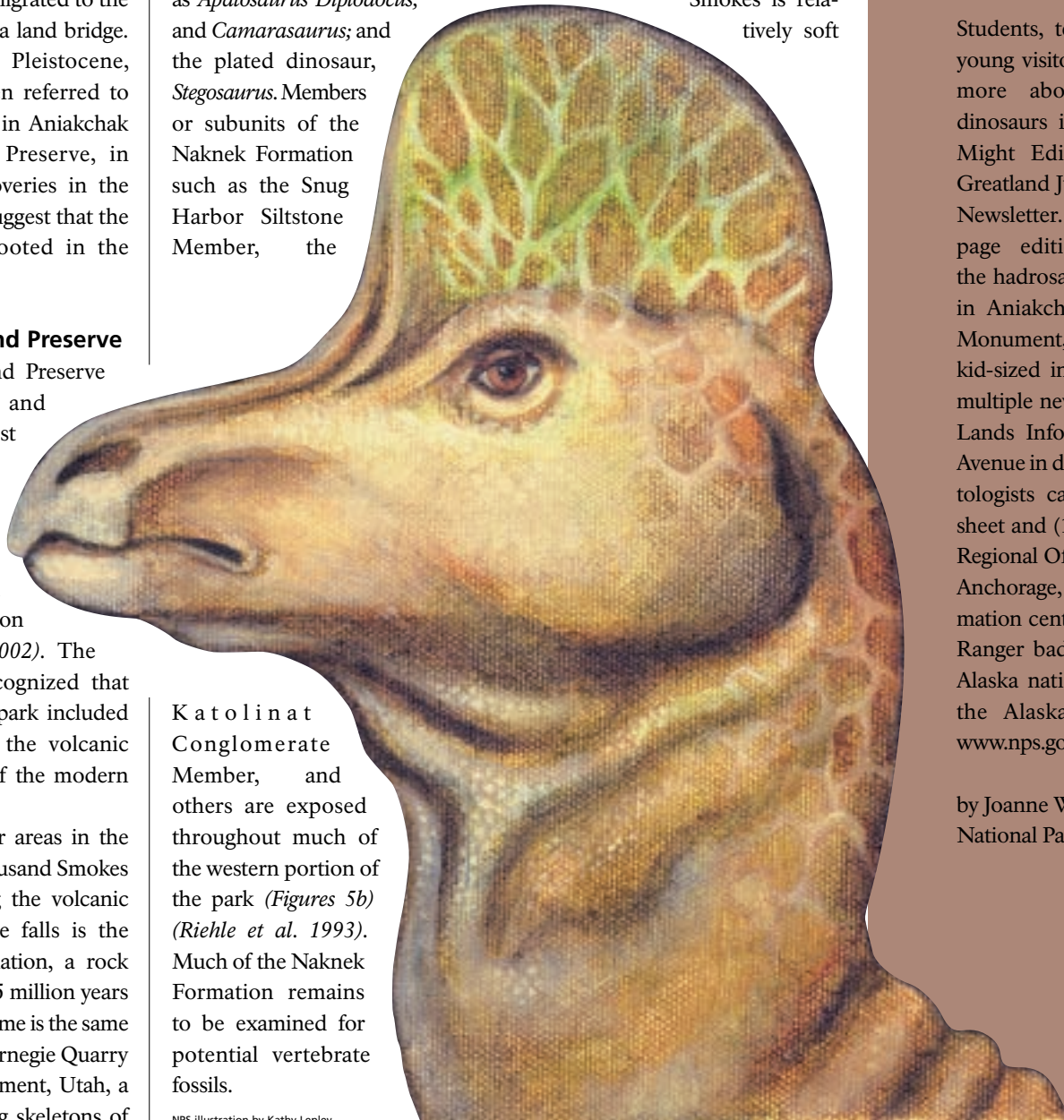
One of the more popular areas in the park is the Valley of Ten Thousand Smokes and Ukak Falls. Underlying the volcanic ash and exposed along the falls is the Jurassic-aged Naknek Formation, a rock unit spanning about 155–145 million years ago (Figure 5a). This slice of time is the same as that represented by the Carnegie Quarry in Dinosaur National Monument, Utah, a quarry famous for producing skeletons of

dinosaurs such as the predator *Allosaurus*; sauropods (a subgroup of the saurischian, or 'lizard-hipped', dinosaurs) such as *Apatosaurus* *Diplodocus*, and *Camarasaurus*; and the plated dinosaur, *Stegosaurus*. Members or subunits of the Naknek Formation such as the Snug Harbor Siltstone Member, the

Whereas the Naknek Formation underlying the Valley of Ten Thousand Smokes is relatively soft

Katoliat Conglomerate Member, and others are exposed throughout much of the western portion of the park (Figures 5b) (Riehle et al. 1993). Much of the Naknek Formation remains to be examined for potential vertebrate fossils.

NPS illustration by Kathy Lepley



Dinosaurs Live On in the Greatland Junior Ranger Newsletter!

Students, teachers, and young visitors can learn more about Alaska's dinosaurs in the Dino-Might Edition of the Greatland Junior Ranger Newsletter. This eight-page edition features the hadrosaur discovery in Aniakchak National Monument, including a



kid-sized interview with Tony Fiorillo. Single or multiple newsletters are available at Alaska Public Lands Information Center at 605 West Fourth Avenue in downtown Anchorage. Budding paleontologists can complete the newsletter's activity sheet and (1) mail it to Traci Parrish at the Alaska Regional Office, 240 West 5th Avenue, Room 114, Anchorage, AK 99501 or (2) drop it off at the information center to receive a certificate and a Junior Ranger badge. A teacher's unit on dinosaurs in Alaska national parks will soon be available on the Alaska Region curriculum web site at www.nps.gov/akso/ParkWise.

by Joanne Welch, Urban Education Program,
National Park Service



Photograph courtesy of Anthony Florillo

Figure 5a. View of the Valley of 10,000 Smokes showing the 1912 eruption ash overlying the Jurassic aged Naknek Formation. The gray rocks by the river are the Naknek Formation.



Photograph courtesy of Anthony Florillo

Figure 5b. Mt. Katolinat, a prominent geographic feature in Katmai National Park, is composed of the Naknek Formation.

further identification is unobtainable. Indeed, in many contexts this bone fragment might have been considered insignificant because of the limited information it can offer. However, this fragment is the first occurrence of a Jurassic dinosaur bone in the entire state of Alaska. This insignificant-looking bone fragment shows that detailed attention to the Jurassic rocks of Alaska will likely produce additional insights into the dinosaurs of that time.

Summary

Fossils are the starting point for understanding life in the past. They provide the means for determining long-term patterns of evolution. They also provide the means for examining how ancient organisms may have interacted among themselves within a community. Arguably, the most popular of all fossils are those of dinosaurs.

Two national parks in Alaska have now provided records of dinosaurs. One such find, the Cretaceous dinosaurs of Aniakchak National Monument and Preserve, offer further insight into ancient high latitude ecosystems as well as the antiquity of Beringia. The other dinosaur find, the single Jurassic bone fragment in Katmai National Park and Preserve, shows that the relatively unstudied Jurassic period also has great potential for contributing to our understanding of dinosaurs in North America. Given the abundance of important fossil-bearing rocks in these and other parks, there are likely many more exciting dinosaur discoveries waiting throughout the Alaska Region of the National Park Service.

and easily worn away, the falls are extant because the river flows over a harder sandstone unit that was an ancient delta. This delta was fed by ancient streams and rivers that carried various types of fossil plant debris (*Figure 6*). This fossil plant debris can be seen exposed in the rocks along Ukak Falls.

An additional fossil found in the ancient delta was a large bone fragment, which was a cobble in an ancient stream bottom (*Figure 7*). Analysis of the bone fragment suggests it is from a dinosaur because of its robust nature, but it is so badly worn



Photograph courtesy of Anthony Fiorillo

Figure 6. Carbonized plant debris found in the ancient delta complex at Ukak Falls.



Photograph courtesy of Anthony Fiorillo

Figure 7. Fossil bone cobble found in the same delta complex at Ukak Falls.

REFERENCES

- Adleman, J. 2002. *The great eruption of 1912*. Alaska Park Science. Winter 2002: 4-11.
- Atwood, W.W. 1911. *Geology and mineral resources of parts of the Alaska Peninsula*. U.S. Geological Survey Bulletin 467.
- Detterman, R.L., J.E. Case, J.W. Miller, F.H. Wilson, and M.E. Yount. 1996. *Stratigraphic framework of the Alaska Peninsula*. United States Geological Survey Bulletin 1969-A, p. 1-74.
- Detterman, R.L., T.P. Miller, M.E. Yount, and F.H. Wilson. 1981. *Geologic map of the Chignik and Sutwik Island Quadrangles, Alaska*. U.S. Geological Survey Miscellaneous Investigations Series, Map I-1229, 1:250,000.
- Fiorillo, A.R. 2004. *Dinosaurs of Alaska and the assembling of Beringia*. Journal of Vertebrate Paleontology, Vol. 24, Supplement to No. 3.
- Fiorillo, A.R., P.J. Armato, and R. Kucinski. 2004. *Wandering rocks in Kenai Fjords National Park*. Alaska Park Science, 3(1): 21-23.
- Fiorillo, A.R., and R.A. Gangloff. 2001. *The caribou migration model for Arctic hadrosaurs (Ornithischia: Dinosauria): a reassessment*. Historical Biology 15: 323-334.
- Fiorillo, A.R., and J.T. Parrish. 2004. *The first record of a Cretaceous dinosaur from western Alaska*. Cretaceous Research 25: 453-458.
- Hillhouse, J.W., and R.S. Coe. 1994. *Paleomagnetic data from Alaska*. In Geology of Alaska edited by G. Plafker and H.C. Berg. The Geological Society of America. Boulder, CO. 797-812.
- Riehle, J.R, R.L. Detterman, M.E. Yount, and J.W. Miller. 1993. *Geologic map of the Mount Katmai Quadrangle and adjacent parts of the Naknek and Afognak Quadrangles, Alaska*. U.S. Geological Survey Miscellaneous Investigations Series, Map I-2204, 1:250,000.
- Wilson, F.H., R.L. Detterman, and G.D. DuBois. 1999. *Digital data for geologic framework of the Alaska Peninsula, southwest Alaska, and the Alaska Peninsula terrane*. U.S. Geological Survey Open-File Report OFR 99-317.